POWER SUPPLY '98
DUAL MODE POWER SUPPLY SPECIFICATION

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1. INTRODUCTION

System-wide architectural enhancements in PC power management technology have mandated a new generation of power supplies. This document defines a low-cost power supply that delivers the features required to achieve the full benefits of the new PC power management architecture. The key new features are: suspend to RAM support, increased standby power to support system wake-up devices and increased efficiency to support emerging regulatory standards.

1.1. SCOPE

This document provides the requirements for switching power supplies that support power management functions. Two different power supplies 200 W and 145W are specified, each with a different maximum power output level. The power supplies are otherwise identical. Each of the supplies provides +3.3 Vdc, +3.3 Vdual, +5 Vdc, +5 Vdual, +12 Vdc, and -12 Vdc at full current and supports power management functions.

The features required for power management operation include the +3.3 Vsby and +5 Vsby outputs, the PS-ON# and DUAL-ON# signals, fan speed control, and high efficiency in the standby operating mode. New motherboard connectors are also required. This document includes information about the physical form factor of the power supply, chassis cooling requirements, connector configurations, and pertinent signal timing specifications.

1.2. APPLICABLE DOCUMENTS

The latest revision in effect of the following documents forms a part of this specification to the extent specified:

CSA C22.2 No.950:	Safety of Information Technology Equipment including Business Equipment
CSA C22.2 No.234, Level 3	Safety of Component Power Supplies. Intended for use with Electronic Data Processing Equipment and Office Machines.
VDE 0871/6.78 or VFG243	Regulations for the Radio Frequency Interference Suppression of High Frequency Apparatus and Installations.
CFR 47 Part 15, Subpart J:	Regulations for Class B Computing Devices
IEEE Std. 587-1980 or IEEE/ ANSI C62.41:	IEEE Guide for Surge Withstand Capability (SWC) Tests for Category A and B.
MIL-STD-105K:	Quality Control
MIL-STD-217E:	Reliability Predictions for Electronic Equipment.
MIL-C-5541:	Chemical Conversion Coatings on Aluminum and Aluminum Alloys.
UL 1950 without D3 Deviation:	Standard for Safety, Information Technology Equipment including electrical Business Equipment.

EN60 950 plus Complete Nordic Deviations	Safety of Information Technology Equipment deviations: (IEC950; 1986-1st Edition, Modified).
CISPR 22:	Limits and Methods of Measurements of Radio Interference Characteristics of Information Technology Equipment, Class B.
TC 110	CENELEC Generic Immunity Standard.
EN55101	Immunity Requirements for Information Technology Equipment. -2 ESD Requirements. -3 Immunity to Radiated Fields. -4 Conducted Immunity.
IEC Publication 1000-3-2	Electromagnetic Compatibility: Limits for harmonic current emissions.
IEC Publication 417	International Graphic Symbol Standard.
ISO Standard 7000	Graphic Symbols for use on Equipment.

2. ELECTRICAL SPECIFICATION

The electrical requirements are to be met over the environmental ranges specified in Section 4, below, unless otherwise noted.

2.1. AC INPUT REQUIREMENTS

The power supply shall support two input voltage ranges for continuous operation, rated 100-120 Vac and 200-240 Vac RMS. The input voltage and frequency requirements for continuous operation are stated below. The input voltage range may be selectable between the two ranges. Note that nominal voltages for test purposes are considered to be within ±1.0 V of nominal.

TABLE 1. AC Input Requirements

Parameter	Minimum	Nominal	Maximum	Unit
100-120 Vac	90	115	132	Vac rms
200-240 Vac	180	230	264	Vac rms
Vac Frequency	47	-	63	Hz

2.1.1. INPUT OVER CURRENT PROTECTION

The power supply shall incorporate primary fusing for input over current protection. Slow blow fuse is recommended.

2.1.2. INRUSH CURRENT LIMITING

Repetitive ON/OFF cycling of the AC input voltage shall not damage the power supply. Half cycle peak inrush current, peak repetitive input current, and worst case power factor data shall be provided to assist with UPS and line conditioning sizing and selection.

2.1.3. LINE TRANSIENTS

2.1.3.1. SLOW TRANSIENTS

The DC outputs shall not exceed the limits specified in Section 2.2.2 as a result of the input power line noise defined in Table 2. In addition, the sag, surge and dropout from standard TC110 and specified in Table 3 shall be met.

The Table 3 input voltage is referenced to the 230 VAC, 50 Hz nominal line.

TABLE 2. Line Voltage Transient Limits:

TRANSIENT EVENT AT THE NOMINAL INPUT LINE FREQUENCY	TYPE	AMPLITUDE RELATIVE TO AC LINE
50 ms-500 ms DURATION	SURGE	+10% above 120/240 Vac
50 ms-500 ms DURATION	SAG	-10% below 100/200 Vac
0.5 ms-10 ms DURATION	SAG	-100% below 100/200 Vac
0.5 ms-8.33 ms DURATION	SURGE	+30% above 120/240 Vac

Note: The power supply shall be loaded to 50% of the maximum load specified in Section 2.2.1

TABLE 3. TC110 Standard Requirements.

TEST EVENT FROM NOMINAL 230 Vac, 50 Hz	DURATION	PERFORMANCE CRITERIA
15% SAG (195.5 Vac, 50 Hz)	15 Min.	No loss of func. or perf.
30% SAG (161.0 Vac, 50 Hz)	10 ms	No loss of func. or perf.
50% SAG (115.0 Vac, 50 Hz)	100 ms	Loss of function allowed, self-recoverable
DROPOUT (0.0 Vac)	500 ms	Loss of function allowed, self-recoverable
10% SURGE	15 Min.	No loss of func. or perf.

Note: The power supply shall be loaded to 50% of maximum load specified in Section 2.2.1. The power supply will need to operate in a worldwide environment. The transient conditions in this environment may exceed the applicable standards in Section 1.3 above. The vendor shall provide recommendations for additional transient limits for the power supply.

2.1.3.2. FAST TRANSIENTS

The power supply shall meet the IEEE Standard 587-1980 for surge withstand capability under categories A and B, with the following conditions and exceptions;

• The crest value of the first half peak of the injected oscillatory wave will be 3.3K volts open circuit with 200 and 500 Ampere short circuit current for the common and the normal modes of transient surge injection, respectively.

• The peak value of the injected unipolar wave form shall be 1.5 KV to 2.0 KV measured at the input of the power supply for the common and the normal modes of transient surge injection.

The power supply must meet the surge withstand test for the environmental conditions of operation specified below. The surge withstand test must not produce damage to the power supply, disrupt the normal operation of the power supply, nor cause the outputs deviate more than ± 5% from nominal voltage. Figure 1 below shows the test setup for the surge withstand test.

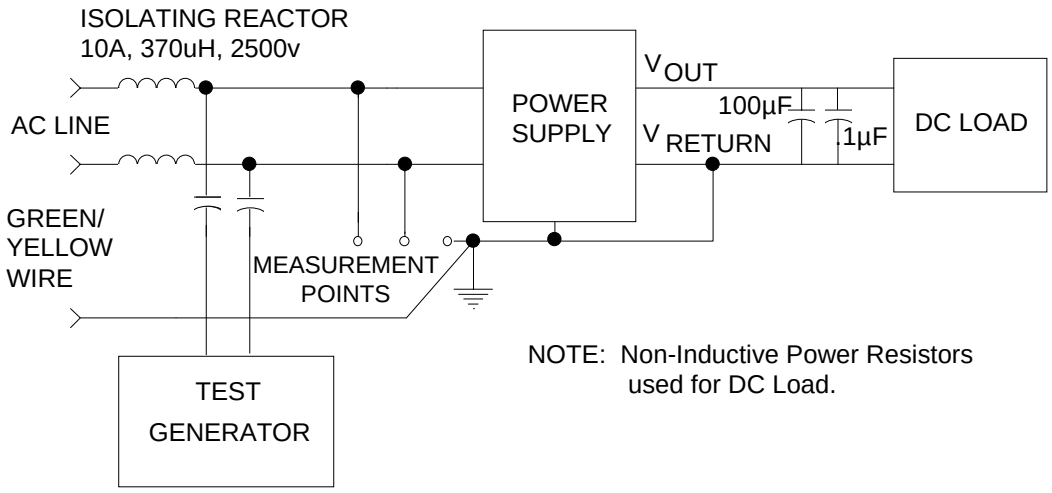

FIGURE 1. Input Surge Withstand Test Block Diagram.

2.1.4. HARMONIC CURRENT LIMITATIONS

This feature is optional.
The power supply shall meet the harmonic current distortion requirements set forth in IEC Publication 1000-3-2, limits for harmonic current emissions.

2.2. DC OUTPUT REQUIREMENTS

In the normal mode of operation all outputs, main, dual mode and standby, are available at full output current. In the standby mode of operation, the standby outputs, +3.3 Vsby and +5 Vsby, are present as long as the power supply is connected to a source of AC voltage as defined in Section 2.1. The dual mode outputs, +3.3 Vdual and +5 Vdual, may or may not be present during standby operation.
Only a small amount of power is available on the dual mode outputs in the standby mode. The dual mode outputs support the suspend to RAM and wakeup features of the desktop platform.

2.2.1. DC OUTPUT CURRENT

The DC output load currents are shown in Table 4 below. The table shows maximum and minimum loads for both normal and standby modes of operation. The minimum load currents shown in Table 4 for the normal operating mode are the values expected during the transition from normal mode to standby mode and back. Regulation on all outputs must be maintained during these transitions. The loads on the dual mode outputs are in standby mode when the PS-ON# signal is in the OFF and the DUAL-ON# is in the ON state and when the PW-OK signal is in the invalid state. Both Table 4 and Table 5 define additional load levels for the system efficiency measurements of Section 2.2.6.

TABLE 4A. DC OUTPUT CURRENT RANGES FOR 200W OUTPUT

Output	Standby Mode Min.	Standby Mode Max.[4]	Normal Mode Min.	Normal Mode Green [1]	Normal Mode Max.[2]	Normal Mode Peak[3]
+3.3 Vdc	-	-	0.0 A	1.0 A	13.0 A	-
+3.3 Vdual	0.0 A	4.0 A	0.0 A	1.0 A	8.0 A	-
+3.3 Vsby	0.0 A	0.5 A	0.1 A	0.1 A	0.5 A	-
+5 Vdc	-	-	0.4 A	1.4 A	16.0 A	-
+5 Vdual	0.0 A	2.5 A	0.0 A	0.2 A	4.0 A	-
+5 Vsby	0.0 A	0.5 A	0.1 A	0.1 A	0.5 A	-
+12 Vdc	-	-	0.0 A	0.0 A	4.5 A	6.0 A
-12 Vdc	-	-	0.0 A	0.0 A	0.5 A	-

Notes:

1 Green is the test load for the efficiency requirements specified in section 2.2.6

2 Maximum continuous DC output power shall not exceed 200 Watts. Maximum current on the 3.3V output will reduce the maximum 5V output below that specified such that the maximum power output will not be exceeded. Similarly, maximum current on the 5 V output reduces the 3.3V maximum current below that specified such that the maximum power output will not be exceeded.3 Peak +12 Vdc output power not to exceed 12 seconds in duration and total DC output power must be less than 220 Watts.

4 Maximum continuous DC output power during standby mode of operation shall not exceed 15 Watts.

TABLE 4B. DC OUTPUT CURRENT RANGES FOR 145W OUTPUT

Output	Standby Mode Min.	Standby Mode Max.[4]	Normal Mode Min.	Normal Mode Green [1]	Normal Mode Max.[2]	Normal Mode Peak[3]
+3.3 Vdc	-	-	0.0 A	1.0 A	9.6 A	-
+3.3 Vdual	0.0 A	3.0 A	0.0 A	1.0 A	6.0 A	-
+3.3 Vsby	0.0 A	0.5 A	0.1 A	0.1 A	0.5 A	-
+5 Vdc	-	-	0.4 A	1.4 A	16.0 A	-
+5 Vdual	0.0 A	2.0 A	0.0 A	0.2 A	3.0 A	-
+5 Vsby	0.0 A	0.5 A	0.1 A	0.1 A	0.5 A	-
+12 Vdc	-	-	0.0 A	0.0 A	1.4 A	4.5 A
-12 Vdc	-	-	0.0 A	0.0 A	0.5 A	-

Notes:

1 Green is the test load for the efficiency requirements specified in section 2.2.6

2 Maximum continuous DC output power shall not exceed 145 Watts. Maximum current on the 3.3V output will reduce the maximum 5V output below that specified such that the maximum power output will not be exceeded. Similarly, maximum current on the 5 V output reduces the 3.3V maximum current below that specified such that the maximum power output will not be exceeded.

[3] Peak +12 Vdc output power not to exceed 12 seconds in duration and total DC output power must be less than 165 Watts.

[4] Maximum continuous DC output power during standby mode of operation shall not exceed 15 Watts.

Table 5. Loading Conditions for 3 Watt Efficiency Measurements

Output Voltage	+5 Vsby and +5 Vdual	+3.3 Vsby and +3.3 Vdual
Condition 1	0.5 A	0.15 A
Condition 2	0 A	0.9 A

2.2.2. DC VOLTAGE REGULATION

The DC output voltages shall remain within the voltage ranges specified in Table 6 below and shall be maintained under continuous operation for a period of time equal to or greater than the MTBF specified in Section 6.2 below for any steady state temperature and operating condition specified in Section 4 below. Regulation of the +3.3 Vsby, +5 Vsby, +3.3 Vdual and +5 Vdual output voltages shall be maintained within the limits specified in Table 6 during the transitions between Normal mode of operation and Standby mode of operation as described in Section 2.2.1 above.

The DC voltage regulation limits include:

- **DC output load ranges as specified in Section 2.2.1**
- **DC output ripple/noise as specified in Section 2.2.3**
- **DC output initial voltage set point**
- **DC output cross regulation**
- **Temperature and warm up drift as specified in Section 4.1**
- **AC input variation and drop out as specified in Section 2.1 and 2.2.4**

TABLE 6. Normal Mode DC Output Voltage Regulation

Output	Min.	Nom.	Max.	Range
+3.3 Vdc	+3.135 V	+3.30 V	+3.465 V	±5%
+3.3 Vdual	+3.135 V	+3.30 V	+3.465 V	±5%
+3.3 Vsby	+3.135 V	+3.30 V	+3.465 V	±5%
+5 Vdc	+4.750 V	+5.00 V	+5.250 V	±5%
+5 Vdual	+4.750 V	+5.00 V	+5.250 V	±5%
+5 Vsby	+4.750 V	+5.00 V	+5.250 V	±5%
+12 Vdc	+11.40 V	+12.00 V	+12.60 V	±5%
-12 Vdc	-10.80 V	-12.00 V	-13.20 V	±10%

TABLE 7. Standby Mode DC Output Voltage Regulation

Output	Min.	Nom.	Max.	Range
+3.3 Vdual	+3.135 V	+3.30 V	+3.465 V	±5%
+3.3 Vsby	+3.135 V	+3.30 V	+3.465 V	±5%
+5 Vdual	+4.750 V	+5.00 V	+5.250 V	±5%
+5 Vsby	+4.750 V	+5.00 V	+5.250 V	±5%

Note: The voltage regulation limits DO include DC Output Noise/Ripple noted in Section 2.2.3 and NOT the voltage deviation due to DC load changes that are covered in Section 2.2.5.

2.2.3. OUTPUT RIPPLE/NOISE

The following output ripple/noise requirements in Table 8 shall be met throughout the load range specified in Section 2.2.1 and under all input voltage conditions as specified in Section 2.1. The specification applies to both normal mode and standby mode operation.

Ripple and noise are defined as periodic or random signals over frequency band of 10 Hz to 30 MHz. Measurements shall be made with an oscilloscope with a minimum of 30 MHz bandwidth. Outputs shall be bypassed at the output connector with a 0.1µF ceramic disk capacitor and a 10 µF electrolytic to simulate system loading. See Figure 2 below.

TABLE 8. DC Output Noise / Ripple

Parameter	Range	Max.
+3.3 Vdc	1.5 %	50 mVpp
+3.3 Vdual	1.5 %	50 mVpp
+3.3 Vsby	1.5 %	50 mVpp
+5 Vdc	1 %	50 mVpp
+5 Vdual	1 %	50 mVpp
+5 Vsby	1 %	50 mVpp
+12 Vdc	1 %	120 mVpp
-12 Vdc	1 %	120 mVpp

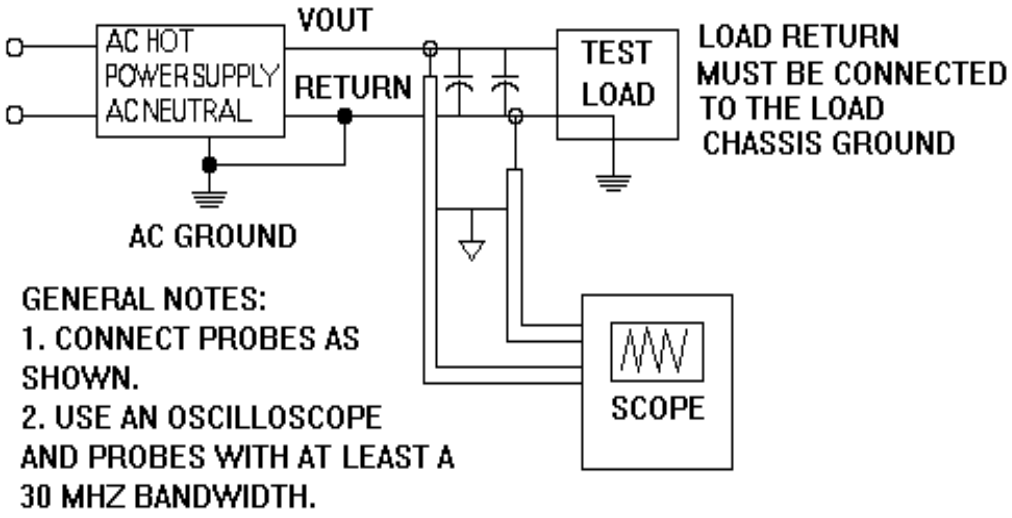

FIGURE 2. - Differential Noise Test Setup

2.2.4. VOLTAGE HOLD-UP TIME

The power supply shall maintain output regulation per Section 2.2.2 for a loss of input power at the low-end of the nominal input voltage range (Low = 100 or 200 VAC RMS, 47 Hz) at maximum output load as specified in Section 2.2.1 for a minimum of 15 ms. The measurement shall be made from the point at which conduction of input current ceases (AC power interrupt) to the point at which the output voltage drops below the static regulation envelope specified in Section 2.2.2.

2.2.5. OUTPUT TRANSIENT RESPONSE

The output voltage shall remain within the voltage range specified in Table 9 below for instantaneous changes in load. The load step shall apply over the full range of values specified in Table 4 in Section 2.2.2. The transient voltage response limits in Table 9 shall be maintained over the AC input range defined in Section 2.1 and all steady state temperature and operating conditions specified in Section 4. The transient voltage limits include the voltage regulation requirements described in Section 2.2.2. The voltage shall recover to be within the regulation band specified in Section 2.2.2 within 2 ms following an instantaneous load change. The transient response measurements shall be made with a load step repetition rate varied over the full range of 50 Hz to 3333 Hz. The load slew rate shall not be greater than 0.40A/µs nor less than 0.1A/µs. The outputs not under test shall be loaded at the minimum value specified in Table 4 in Section 2.2.2.

TABLE 9. DC Output Transient Response

DC Output	Load Step	Min.	Nom.	Max.	Range
+3.3 Vdc	5.0 A	+3.135 V	+3.30 V	+3.465 V	±5%
+3.3 Vdual	5.0 A	+3.135 V	+3.30 V	+3.465 V	±5%
+3.3 Vsby	0.5 A	+3.135 V	+3.30 V	+3.465 V	±5%
+5 Vdc	5.0 A	+4.750 V	+5.00 V	+5.250 V	±5%
+5 Vdual	4.0 A	+4.750 V	+5.00 V	+5.250 V	±5%
+5 Vsby	0.5 A	+4.750 V	+5.00 V	+5.250 V	±5%
+12 Vdc	2.0 A	+11.40 V	+12.00 V	+12.60 V	±5%
-12 Vdc	0.5 A	-10.80 V	-12.00 V	-13.20 V	±10%

2.2.6. EFFICIENCY

The overall efficiency of the power supply shall be within the range specified in Table 10 below and shall be met over the AC input range defined in Section 2.1, under the load conditions defined in Section 2.2.1, and the temperature and operating conditions defined in Section 4. The Standby 3 Watt load condition has two different load current combinations and the minimum efficiency must be met for both conditions. Efficiency is defined as the ratio of total DC output power divided by the total AC input power.

TABLE 10. Power Supply Efficiency

Parameter	Minimum Efficiency
Maximum load	65 %
Green load	50 %
Standby maximum load	65 %
Standby 3 Watt load	60 %

2.2.7. OVERSHOOT AT TURN-ON / TURN-OFF

Any overshoot upon the application or removal of the input voltage or the PS-ON#, DUAL-ON# signals under the conditions specified in Section 2.1 shall be less than 10% above the initial set voltage. No voltage of opposite polarity shall be present on any output during turn-on or turn-off.

2.2.8. SEQUENCING

The 3.3 Vdc outputs shall track the +5 Vdc outputs and there shall not be greater than 0.5 volts difference between them during turn-on and turn-off of the outputs. It is preferred that the 3.3 Vdc outputs be slightly lower than the 5 Vdc outputs during turn-on and turn-off. This applies to both the main and the dual outputs. In addition, if both the main and the dual outputs are turning on at the same time, such as after a power failure or fault condition, then they shall track each other and there shall not be greater than 0.5 volts difference among them.

2.2.9. MONOTONICITY AT TURN-ON

The outputs of the power supply shall rise monotonically. At no time during turn-on of any of the outputs shall the derivative of the output voltage change sign until the voltage enters the regulation band defined in Section 2.2.2.

2.2.10. TURN ON/OFF DELAY

The output voltages shall settle to a point within the range specified in Section 2.2.2 above within 1.0 second after power is applied to the unit or the PS-ON# signal is exerted. The DC outputs must rise from 20% of their nominal output level to within the regulation band while loaded as specified in Section 2.2.1

It is recommended to reduce the turn on time to reduce the overall system resume delay.

2.2.11. CLOSED LOOP STABILITY

The power supply vendor shall provide proof of unit closed-loop stability with local and remote sensing through the submission of Bode plots and/or root-locus test data for all regulated outputs. Closed-loop stability must be ensured at all loads specified in Section 2.2.1 and over the input voltage range specified in Section 2.1 above.

2.2.12. Vdual OUTPUTS

The +3.3 Vdual, and +5 Vdual outputs are controlled by both PS-ON# and DUAL-ON# signals. The operation of the dual outputs is described in the Table 11.

A fault on either the +3.3 Vdual or +5 Vdual output, sensed as either an over current condition or an under voltage condition, shall cause the dual outputs to be turned off.

In certain applications dual outputs and the main outputs may be shorted together. (For example +3.3 Vdual and +3.3 may be shorted together). It is required for the power supply to operate normally at this condition. The maximum current drawn from the combined output (dual and normal shorted) will not exceed the max current specified for the main output.

Table 11. Power Supply Operating States.

PS-ON#	DUAL-ON#	Conditions	Standby Outputs	Dual Outputs	Main Outputs
1	1	Soft OFF state	ON	OFF	OFF
0	1	Compatibility state - will not be used by the new systems	ON	OFF	ON
1	0	Suspend state	ON	ON (low capacity output current)	OFF
0	0	Normal operation	ON	ON (high capacity output current)	ON

* 0 - indicates voltage level low.
  1 - indicates voltage level high. It can be either +3.3V or +5V.

2.2.13. STANDBY OUTPUTS

The +3.3 Vsby and +5 Vsby outputs are always present when the power supply is connected to a source of AC voltage as defined in Section 2.1.

2.2.14. 1394V OUTPUT

This output voltage, required to support the IEEE 1394 serial bus, is optional.

The 1394V output is an isolated output voltage that supports unbiased devices on the IEEE 1394 serial bus. This output allows for implementation of a segregated voltage supply rail for use with unpowered 1394 solutions. The power derived from this output shall be used only to power 1394 connectors. The 1394V output shall be 26 +/- 6V and shall provide a maximum of 30 watts of output power. Maximum output current is 1.5 Amps at 20 V output. The minimum output current is 0.0 A. Output ripple voltage is 400mVpp max. The power supply manufacturer may specify the nominal output voltage within the range given above. When implemented this output must be over voltage and short circuit protected according to IEEE 1394 standard.

The 1394 output requires an isolated ground path for unpowered 1394 implementations. This ground shall be used only for 1394 connections.

2.3. CONTROL SIGNALS

2.3.1. REMOTE SENSE

A remote sense line shall be implemented for the main +3.3 Vdc and +3.3 Vdual outputs. This is to compensate for voltage drops in the wiring harness and connector.

2.3.2. POWER ON SIGNAL

PS-ON# is an active low control input to the power supply. PS-ON# turns on the +3.3 Vdc, +5 Vdc, +12 Vdc, -12 Vdc and 1394 V outputs. When this signal is held high by the PC motherboard, or is open circuit, the power supply shall be held in the standby mode of operation and the +3.3 Vdc, +5 Vdc, +12 Vdc, -12 Vdc and 1394 V outputs shall be at zero volts. The operation of the +3.3 Vdual and +5 Vdual outputs is defined in Section 2.2.12. The PS-ON# signal shall have no effect on the +3.3 Vsby and +5 Vsby outputs. The PS-ON# is a +3.3V signal however the power supply input buffer must be +5V tolerant.

2.3.3. DUAL POWER ON SIGNAL

DUAL-ON# is an active low control input to the power supply. DUAL-ON# turns on the +3.3 Vdual and +5 Vdual outputs into their normal mode of operation. When this signal is held high by the PC motherboard, or is open circuit, the dual outputs shall be at zero volts. The operation of the +3.3 Vdual and +5 Vdual outputs is defined in Section 2.2.12. The DUAL-ON# signal shall have no effect on the +3.3 Vsby and +5 Vsby outputs. The DUAL-ON# signal is a +3.3V signal however the power supply input buffer must be +5V tolerant.

2.3.4. MAIN POWER GOOD SIGNAL

PW-OK is a power good signal and shall be asserted high by the power supply to indicate that the +5 Vdc and +3.3 Vdc outputs are above the under-voltage thresholds of the power supply. When this signal is asserted high, there shall be sufficient mains energy stored by the power supply to guarantee full power continuous operation within specification for the time period specified in Section 2.2.5. Conversely, when either the +5 Vdc or +3.3 Vdc output voltage falls below the under-voltage threshold, or when mains power has been removed for a time sufficiently long so that power supply operation is no longer guaranteed, PW-OK shall be reasserted to a low state. See Section 2.3.5 for a representation of the timing characteristics of the PW-OK and PS-ON# signals and representative output voltages. This signal is open collector and requires a 10K-ohm pull-up resistor to +3.3 Vsby or +5 Vsby external to the power supply.

2.3.5. DUAL POWER GOOD SIGNAL

DLPW-OK is a power good signal and shall be asserted high by the power supply to indicate that the +3.3 Vdual and +5 Vdual outputs are above the under-voltage threshold of the power supply. When this signal is asserted high, there shall be sufficient mains energy stored by the power supply to guarantee full power continuous operation within specification for the time period specified in Section 2.2.5. Conversely, when either the +3.3 Vdual or the +5 Vdual output voltage falls below the under-voltage threshold, or when mains power has been removed for a time sufficiently long so that power supply operation is no longer guaranteed, DLPW-OK shall be reasserted to a low state. This signal is open collector signal and requires a 10K-ohm pull-up resistor to +3.3 Vsby or +5 Vsby external to the power supply.

2.3.6. SIGNAL TIMING

Figure 3 is a reference for signal timing for main power connector signals and rails. This figure applies to PW-OK for all transitions of the PS-ON signal and it applies to DLPW-OK for initial turn-on of the Dual voltages.

It is recommended to reduce the time from when the PS-ON# is active to the time when PW-OK is valid. Reducing this time will reduce the overall system resume latency.

The timing relationships are:

$2\ ms \leq T_2 \leq 200\ ms,\ 50\ ms < T_3 < 500\ ms,\ T_4 > 1\ ms,\ T_5 \leq 1\ ms$

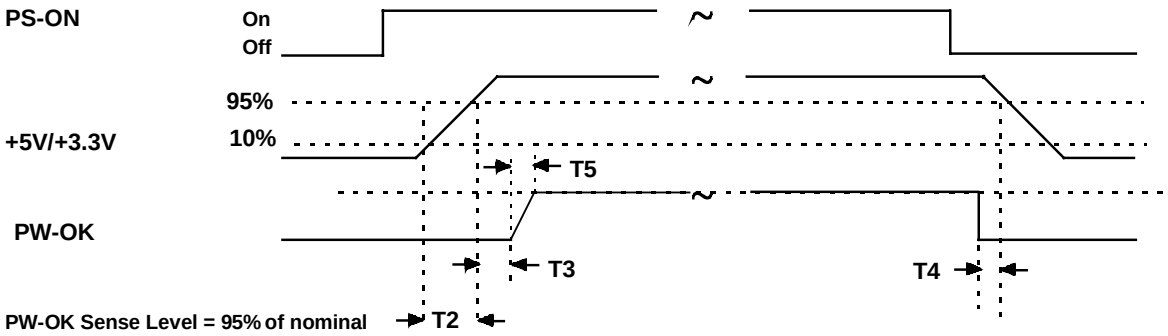

Figure 3. Timing of PS-ON#, PW-OK, and Germane Voltage Rails

2.3.7. FAN SPEED CONTROL SIGNAL

The fan speed is controlled by a pulse width modulated signal and has a control range of 20% to 100% of rated fan speed. The fan speed control signal (FanCon) has a range of 0-3.3V and requires a 10K ohm pull-up resistor internal to the power supply. Fan off is zero volts. This input must be able to accept an input voltage as great as 12Vdc without damage and this input shall cause the fan to run at maximum speed. A fan rated for PWM operation is required. The frequency of the FanCon pulse width modulated signal shall be in the range of 25 kHz 50kHz.

2.3.8. FANRPM SIGNAL

The Fanrpm signal is a fan monitor signal supplied by the power supply to the motherboard. It is an open collector, 2 pulse per revolution tachometer signal from the power supply fan. The signal stops cycling during a lock rotor state; the level can be either high or low. This signal allows the system to monitor the power supply for fan speed or failures. Implementation of this signal allows a system designer to gracefully power down the system in the case of a critical fan failure. The monitoring circuit on the motherboard uses a 1k Ohm to 10k Ohm pull up resistor to +3.3 Vdc for this signal.

2.3.9. FAN CONTROL OVERRIDE

The fan control signals are request signals and shall be overridden if the temperature in the power supply exceeds 52.5 +/- 2.5 degrees Celsius. In this case the fan control shall operate the fan at maximum speed until the temperature is below 42.5 +/-2.5 degrees. The fan speed shall then return to the speed set by the fan speed control signals.

2.4. PROTECTION

2.4.1. OVER VOLTAGE PROTECTION

The supply shall provide latch-mode over voltage protection as defined in Table 13. The power supply shall latch off if the output voltages exceed the threshold defined in Table 13.

TABLE 13. Over Voltage Protection

Parameter	Min.	Nom.	Max.	Unit
+3.3 Vdc	3.70	4.00	4.40	V
+3.3 Vdual	3.70	4.00	4.40	V
+5 Vdc	5.58	6.00	6.82	V
+5 Vdual	5.58	6.00	6.82	V
+12 Vdc	-	-	-	V
-12 Vdc	-	-	-	V

2.4.2. SHORT CIRCUIT PROTECTION

The power supply shall withstand a continuous short-circuit to any output without damage or over stress to the unit (components, PCB traces, connectors, etc.) under the AC input conditions specified in Section 2.1 above. The maximum short-circuit current in any output shall not exceed the limits of Section 2.4.3 and Section 7.2. The power supply may latch off during a short-circuit condition.

2.4.3. OVER CURRENT PROTECTION

Overload current applied to each tested output rail will cause the output to trip when they reach or exceed 240 VA. Each output rail shall be tested for over current protection with a minimum of 10A/s fault current ramp starting from full load

It is optional however recommended for the power supply to provide over current protection as noted in Table 14 below.

TABLE 14. Over Current Protection

Parameter	Type	Nom.	Max.	Unit
+3.3 Vdc	OCP	-	<1.5 X (Imax + Dual Imax)	Amps
+3.3 Vdual	OCP	-	<1.5 X (Imax + Dual Imax)	Amps
+5 Vdc	OCP	-	<1.3 X Imax	Amps
+5 Vdual	OCP	-	<1.3 X 5V Imax	Amps
+12 Vdc	OCP	-	<1.5 X 12V Imax	Amps
-12 Vdc	-	-	<-2	Amps

2.4.4. RESET AFTER SHUTDOWN

If the power supply latches into a shutdown state due to fault condition on its outputs, the power supply shall return to normal operation only after the fault has been removed and supply power-on switch has been cycled on-off.

3. MECHANICAL REQUIREMENTS

3.1. PHYSICAL DIMENSIONS/MARKINGS

The supply shall be 86 mm (h) x 150 mm (w) x 140 mm (d) (standard Baby-AT chassis compatible) and meet the physical outline shown in Figure 4. **In addition**, **each supply shall be marked as follows:**

• Manufacturer's name, part number, lot date code.
• Serial number is optional and shall be the same as the bar code label if present.
• A warning label.
• AC input operating voltages (100-120 Vac and 200-240 Vac) and current rating certified by UL, CSA, TUV, and a NORDIC CENELEC certifier such as NEMKO.
• Hi-pot marking per section 7.1 below.

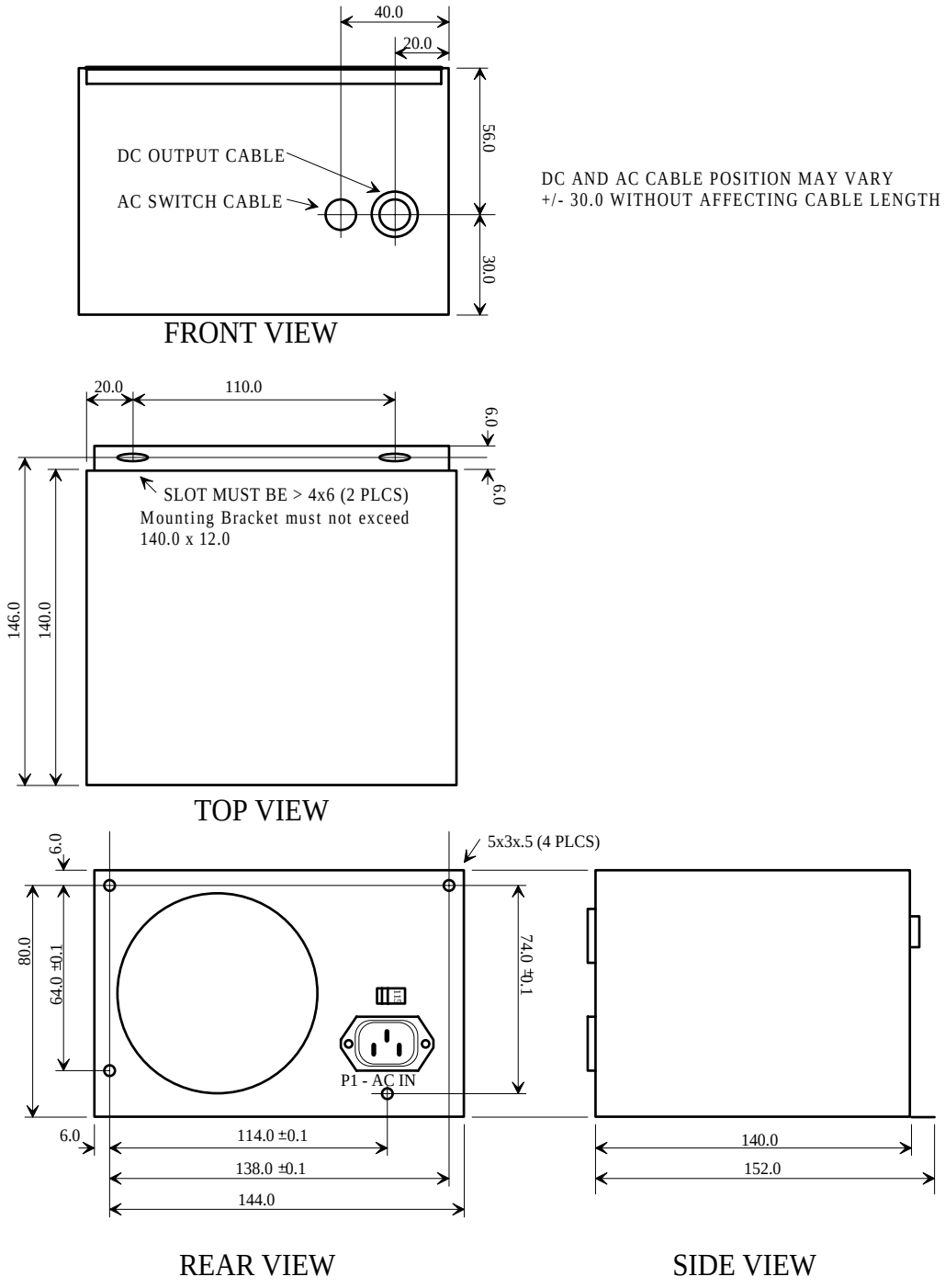

Figure 4. Dimensions of power supply chassis and connector location.

3.2. ACOUSTIC NOISE REQUIREMENTS

The average of the worst case measured fan noise shall not exceed 35.0 dBA with the fan operating at maximum speed and at an external system ambient temperature of 25 ºC ±2 ºC. The sound pressure level of the fan shall be measured at a distance of 1.0 meter from each side of the power supply, in a free field.

3.3. AIR FLOW

This power supply is designed to provide maximum airflow to cool both the power supply and integrated system devices. The exact venting location and geometry as well as fan selection for the power supply will vary, depending on the complete system solution being implemented.

The minimum airflow through the chassis shall be as defined in Table 15 when measured at the outlet of the power supply. The configuration of the power supply vents on the outside of the system should provide the least possible restriction on the airflow. The minimum airflow is determined from Table 15 according to the maximum power output of the power supply.

Tradeoffs exist between airflow, acoustical noise generated by the system, and cost. Structures that attempt to control or restrict airflow will generate acoustical noise and should be designed to provide the minimum noise levels achievable. Well-vented systems with low flow impedance may allow the use of quieter, lower power fans.

Table 15. Minimum Airflow from Power Supply

Power Output	Airflow	Units
145W	20	CFM
200W	30	CFM

3.4. AC CONNECTOR REQUIREMENTS

The power supply shall incorporate a manual AC input select between 90-132 Vac range and 180-264 Vac. The AC input receptacle shall conform to the requirements specified in CEE 22.6 for an IEC 320 C14 type connector.

An auxiliary AC output receptacle is not required as part of this specification, but may be included.

3.5. DC CONNECTOR REQUIREMENTS

3.5.1. LOGIC CONNECTORS

Table 16 and Table 17 show the connector pinouts for the main outputs. There are two connectors, P2 and P3, to deliver the power supply output voltages and control signals to the motherboard.

The main connector P2 is a Molex connector PN 39-01-2240. This connector mates with motherboard connector PN 39-29-9242. (This is the same style connector as used in ATX power supplies but with 24 pins instead of 20 pins). All wires are 18 AWG and the cable length external to the chassis is 250 mm minimum. The pinout of the connector is given in Table 16.

Connector P3 is a small connector with 0.1 inch center dual row pins. The wires may be either 26 AWG ribbon cable or 24 AWG wires. The connector is rated at 1A per pin.
The P3 power supply connector is Molex 22-55-3201. The P3 connector from the power supply mates with the motherboard connector Molex 70246-2021
The pinout for this connector is given in Table 17.

Table 16: Wire Color Code for Power Supply Connector P2

18 AWG Wire	Signal	Pin	Pin	Signal	18 AWG Wire
Gray	+5 Vdual	13	1	COM	Black
White	+3.3 Vdual	14	2	COM	Black
White	+3.3 Vdual	15	3	COM	Black
	Reserved	16	4	COM	Black
Orange	+3.3 V	17	5	COM	Black
Orange	+3.3 V	18	6	COM	Black
Orange	+3.3 V	19	7	COM	Black
	Reserved	20	8	COM	Black
Red	+5 Vdc	21	9	Reserved	
Red	+5 Vdc	22	10	1394 V	Violet
Red	+5 Vdc	23	11	1394 R	Brown
Red	+5 Vdc	24	12	+12 Vdc	Yellow

Table 17: Wire Color Code for Power Supply Connector P3

24 AWG Wire or ribbon cable	Signal	Pin	Pin	Signal	24 AWG Wire or ribbon cable
Red	+5 Vsby	1	2	PS-ON#	Green
Orange	+3.3 Vsby	3	4	Dual-ON#	Yellow
White	3.3 Vdual sense	5	6	COM	Black
Black	COM	7	8	COM	Black
Brown	3.3 V sense	9	10	Reserved	
Violet	DLPW-OK	11	12	Reserved	
Gray	PW-OK	13	14	COM	Black
Blue	-12 VDC	15	16	Fanrpm	White
Black	COM	17	18	FanCon	Yellow
	Reserved	19	20	Reserved	

Note: Color cable requirement does not have to be met if the ribbon cable is used.

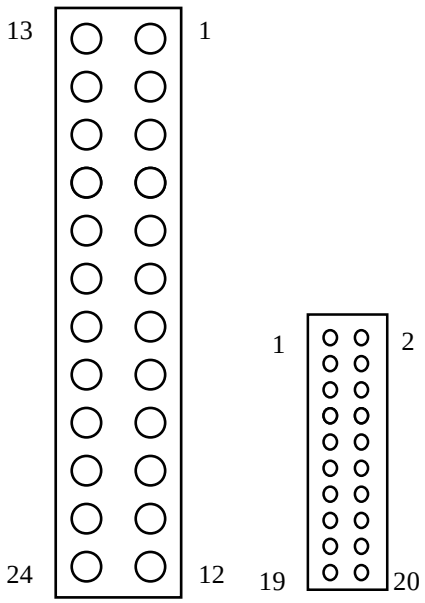

Figure 5. Main power connectors P2 and P3 configuration
This is a top view of the power supply connector when it is plugged into the motherboard looking from the wires side or the top view of the motherboard connector. (component side)

3.5.2. PERIPHERAL CONNECTORS

These outputs provide power to the disk drives and other peripherals in the system. The minimum cable length is 300 mm for P4, P5, P6 and P7. P8 is daisy chained from P5 and P9 is daisy chained from P7. The length of the daisy chain cables is 100 mm minimum.

Table 18. Peripheral Connector Pinouts

P4, P5, P6, P7 AMP 1-480424-0 or MOLEX 8981-04P or equiv.

Pin	Signal	18 AWG Wire
1	+12 Vdc	Yellow
2	COM	Black
3	COM	Black
4	+5 Vdc	Red

P8, P9 AMP 171822-4 or equivalent

Pin	Signal	26 AWG Wire
1	+5 Vdc	Red
2	COM	Black
3	COM	Black
4	+12 Vdc	Yellow

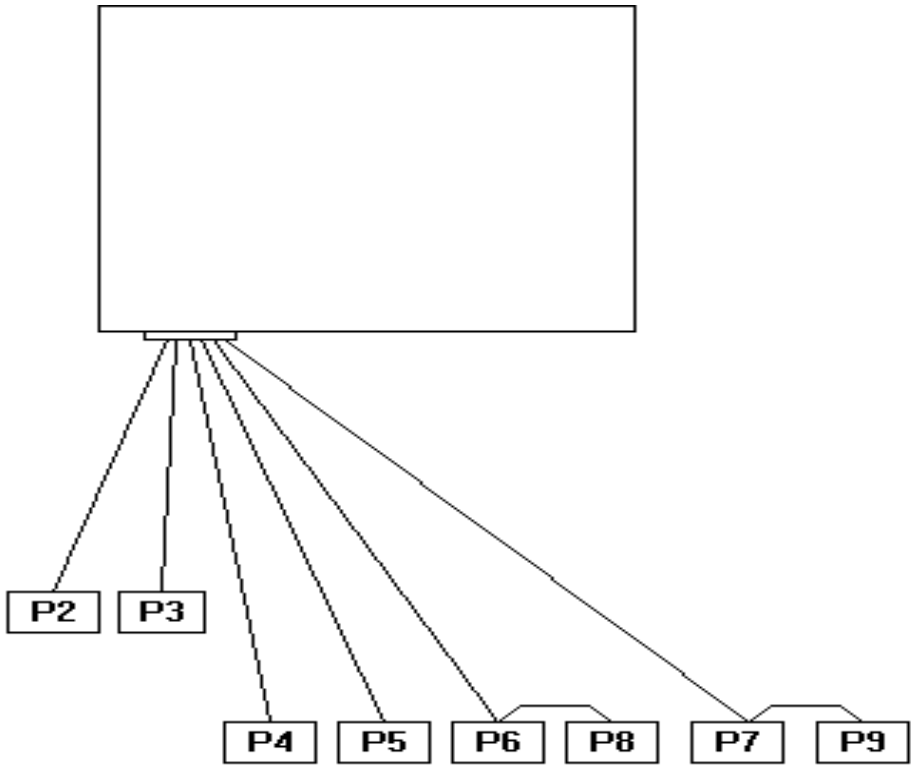

Figure 6. Connector Harness Assembly

3.6. ACCESSIBILITY

There shall be no internal parts accessible externally on the power supply.

4. ENVIRONMENTAL REQUIREMENTS

4.1. TEMPERATURE

Operating Ambient: 10°C to +50°C at full load with a maximum rate of change of 5°C/10 minutes minimum but no more than 10°C/hour.

Non-operating Ambient: -40°C to 70°C with a maximum rate of change of 20°C/hour.

4.2. HUMIDITY

Operating: 0 to 85% relative humidity.

Non-Operating: 0 to 95% relative humidity.

NOTE: 95% relative humidity is achieved with a dry bulb temperature of 55°C and a wet bulb temperature of 54°C.

4.3. MECHANICAL SHOCK

The power supply shall not be damaged during a shock of 30G with an 11 millisecond half sine wave, non-operating. The shock to be applied in each of the orthogonal axes.

4.4. RANDOM VIBRATION

$0.01G^2$ per Hz at 5 Hz, sloping to $0.02G^2$ per Hz at 20 Hz and maintaining $0.02G^2$ per Hz from 20 Hz to 500 Hz.

4.5. ALTITUDE

Operating: 0 to 10,000 feet.

Non-Operating: to 50,000 feet.

4.6. THERMAL SHOCK (SHIPPING)

The Thermal shock -40°C to +70°C, non-operating, 10 cycles, transfer time shall not exceed 5 minutes, duration of exposure to temperature extremes shall be 20 minutes.

4.7. ELECTROSTATIC DISCHARGE

The power supply shall withstand a minimum ESD initialization level of 15 KV while operating without any DC output exceeding the regulation limits specified in Section 2.2.2. The power supply shall not experience any nuisance trips of the overvoltage protection or overcurrent protection circuits when subjected to 15 KV impulses. Further, the power supply shall not sustain any component damage when subjected to a 25 KV ESD initialization level. The test conditions and setup shall conform to that outlined in EN55101-2 or CISPR24-2.

The power supply shall also comply with EN55101-2 when subjected to the 3 KV contact specification and 8 KV air discharge specification.

5. ELECTROMAGNETIC COMPATIBILITY

5.1. RADIO FREQUENCY INTERFERENCE (RFI)

The power supply shall comply with the conducted and radiated emission limits set forth in the FCC regulation for Class B computing devices, Part 15, Subpart J, Class B and the German regulation VDE 0871 Level B. Tests shall be conducted using a shielded DC output cable to a shielded load. The load shall be adjusted as follows for three tests: No load on each output; 50% load on each output; and 100% load on each output as specified in Section 2.2.1.

5.2. IMMUNITY TO RADIATED FIELDS

The power supply must be in compliance with EN55101-3 or CISPR24-3 for immunity to radiated fields and the criteria specified in Table 19.

TABLE 19. Electromagnetic Fields

Frequency Range (MHz)	Field Strength (V/m)	Modulation (AM)	Performance Criteria
26-1000	3.0	1 KHz at 80%	Continues to operate as intended. No degradation of performance

5.3. CONDUCTED IMMUNITY

The power supply must be in compliance with EN55101-4 or CISPR24-4 for conducted immunity and the criteria specified in Table 20.

TABLE 20. Conducted Radio Frequency Disturbances

Frequency Range (MHz)	Interference Voltage (Vemf)	Modulation (AM)	Performance Criteria
0.15 - 100 [1]	3.0	1 KHz at 80%	Continues to operate as intended. No degradation of performance

[1] Test performed with frequency steps of 100 KHz at a dwell time of 2 sec/step

6. RELIABILITY

6.1. COMPONENT DERATING

The following component derating guidelines shall be followed:

- Semiconductor junction temperatures shall be less than 105°C with ambient at 50°C.
- Inductor case temperature shall not exceed safety agency requirements.
- Capacitor case temperature shall not exceed 95% of rated temperature.
- Resistor wattage derating shall be greater than 30%.
- Component voltage and current derating shall be greater than 10%.

6.2. MEAN-TIME-BETWEEN-FAILURES (MTBF)

The demonstrated MTBF shall be 50,000 hours minimum of continuous operation at 55°C, maximum output load, and worst case line, while meeting all specified requirements. Nominal input voltage shall be used while meeting all specified requirements at 80% Confidence Level. The MTBF of the power supply shall be calculated in accordance with MIL-STD-217E.

7. SAFETY REQUIREMENTS

7.1. UL

The Power Supply must be UL Recognized under the following conditions:

Must be UL Recognized for use in Information Technology Equipment including Electrical Business Equipment per UL 1950, without D3 deviations.

Must have a full compliment of tests conducted as part of the UL Recognition, such as input current, leakage current, hipot, temperature, and thermocouple locations, transformer output characterization test (open circuit voltage, short circuit current and maximum VA output), and abnormal testing (to include stalled fan tests).

The Supplier must supply the complete UL Recognition Report including Test Record. The "Conditions of Acceptability" must be approved by Intel prior to full qualification.

Production hipot testing must be included as a part of the UL Recognition and indicated as such in the Conditions of Acceptability. Minimum primary to secondary dielectric withstand test per UL 1950 for reinforced insulation.

There must not be unusual or difficult Conditions of Acceptability such as mandatory additional cooling, power derating or the class of UL insulation system shall not have temperatures exceeding their rating when tested in our system.

The UL Recognition Mark (Backward UR) shall be marked on each power supply.

A list of temperature ratings of all components and printed circuit board shall be provided.

7.2. CSA

The power supply must be CSA certified under the following conditions:

Must be certified per the Standard for Safety of Information Processing and Business Equipment, CSA C22.2 No. 950.

Must be evaluated for operator accessible secondary outputs (reinforced insulation), per CSA C22.2 No. 234, Level 3, that meets the requirements for SELV and that, under any condition of output loading, does not exceed 240 VA.

The proper polarity between the AC Input receptacle, the AC Output receptacle, and any Printed Wiring Boards connections must be maintained.

7.3. INTERNATIONAL

The power supply must be certified under the following conditions by any NORDIC CENELEC certifier, such as SEMKO, NEMKO, DEMKO, or SETI. The supplier must provide copies of certificates verifying certification by one of the referenced certification organizations.

The power supply must be certified to EN60 950 including the complete Nordic Deviations. All evaluations and certifications must be for reinforced insulation between primary and secondary circuits.

7.4. GERMANY

The power supply must bear the German Bauart Mark from TUV or VDE.

The power supply must be certified to IEC 950 (1986 - 1st edition, modified) for use in Information Technology Equipment including Electrical Business Equipment.

8. DOCUMENTATION

The power supply manufacturer shall provide Intel with the following documentation for the power supply and relevant components under the plan outlined below.

- I.C., transistor and regulator component specifications.
- Discrete component specifications including transformer construction drawings.
- Power supply drawings, both detail and assembly.
- Parts list (including certification AC components where applicable).
- Schematics.
- Technical and circuit descriptions, including theory of operation.
- MTBF calculations per Section 6.0.
- Bode plot or Root-Locus stability test data per Section 2.2.10.
- Certification documents and reports per Section 7.0